They still can't count

assessing and supporting children's counting difficulties in the early years of schooling

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By using a diagnostic instrument to identify areas of strength and weakness, the sub-skills of counting needed to be worked on are found. In this way teachers are able to better target their teaching in order to assist all students to become successful counters.

The ability to count is a cornerstone for many life skills. In our classroom, we were concerned that after 12 months of our best efforts to teach counting skills to 5–7 year olds, only about 30 percent of them could correctly respond to the following simple counting tasks:

1. Forward number counting from one.
2. How many blocks are there? (five)
3. Give me eight blocks (from a pile of 12).

Our population of students is a special one. At the Glenleighden School, in a leafy western Brisbane suburb, we are the early childhood teachers working in collaboration with a multi-disciplinary team that supports children with speech and language difficulties. Many of the children not only have communication challenges but also fine and gross motor problems, limited working memory, social or emotional difficulties, short attention spans, and a reduced conceptual understanding of the purposes of counting. Mathematically, our students typically have difficulty reciting counting patterns, understanding symbols such as numerals, and are challenged when invited to verbalise their thinking. Children with such learning profiles can also be found in mainstream classes giving resonance to the issues highlighted in this article.

We were not going to give up on the problem of how to facilitate improved counting skills for the children at our school. We were determined to find answers, starting by immersing ourselves in the research literature. We were pleased to find a range of research articles from many disciplines which had focussed on the issue of children's counting. These articles provided unique ideas that could potentially be of help to our students. We could not, however, find any articles that translated this body of research knowledge in practical ways for teachers to use with young children in their classrooms.

As a result of our research investigations we developed a diagnostic observational assessment form, the Glenleighden Counting Analysis. Just as English teachers regularly complete a 'running record' to record and analyse a child's reading behaviours, The Glenleighden Counting Analysis can be used to record and carefully analyse children's counting activities. We found it useful, at the start of the year, to video our students completing the three tasks posed at the beginning of this article, analysing them with the Glenleighden Counting Analysis. It was liberating to discover that even our most challenged students had identifiable strengths. Following the analysis we were able to create activities that targeted each child's specific weakness rather than wasting scarce instruction time on aspects of counting in which they already demonstrated competence.

Practical ideas for improving counting skills: Ideas from the research literature

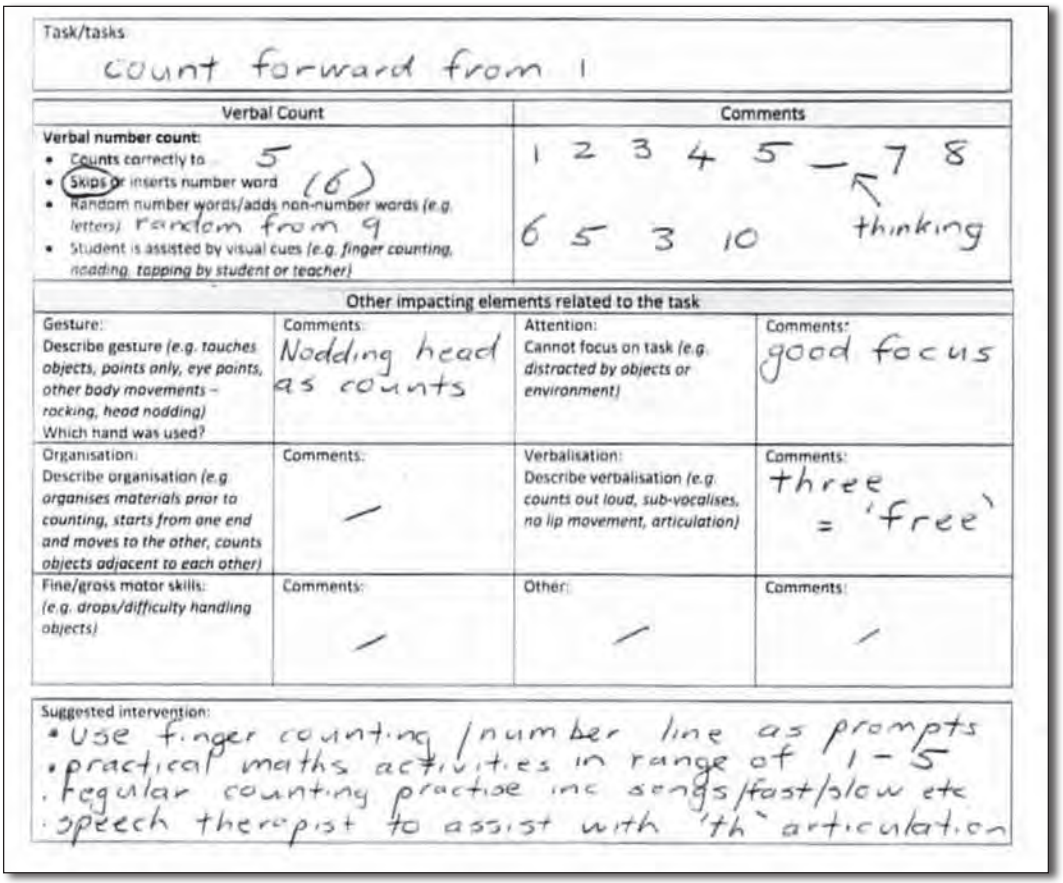
What follows is a summary of some of the most interesting research about counting that may be unfamiliar to teachers. Many of these ideas enabled us to implement immediate, simple and practical changes in our programming.

At its most basic level, the counting process has three essential elements. First, number words need to be recited in a non-negotiable order. Second, each item to be counted must be tagged with a number word using accurate one-to-one correspondence. Finally, children develop an understanding that the last number in the count represents the total number of items or the cardinality of the group. These three aspects need to be fully integrated for a count to be meaningful.

Many researchers use an analysis of error patterns to clearly define these elements of children's counting behaviours (Baroody, 1986; Bashash, Outhred & Bochner, 2003; Fazio, 1996; Fuson, 1988). Common counting errors in this research literature include skipping, inserting or randomly reciting number words.

Children may start with an accurate count and, once this is exhausted, move to a random number sequence. Occasionally children may use non-number words in their sequence. Counting difficulties may be due to word retrieval difficulties, articulation of the words themselves or problems with the sequential nature of the task (Fazio, 1996). Figure 1 shows how a section of the form can be used to analyse a simple forward count. To remediate this common problem our children are encouraged to count as many times a day as possible: quickly or slowly; loudly or softly; steadily or in a stop/start fashion; and in isolation or with accompanying body movements.

Children may have difficulties in making one-to-one correspondence between their gestural actions and verbal count. This may result in double counting, skipping over objects, continuing to count after the objects have been accounted for, or stopping counting before all the objects have been considered. For children experiencing difficulties with this, we separate out the gestural action and the verbal count, allowing the child to count as we gesture or vice versa. As the children gain increased confidence, they practise doing both elements simultaneously, initially just with


Task/tasks: count forward from 1

Verbal Count	Comments
Verbal number count: • Counts correctly to 5 • Skips or inserts number word (6) • Random number words/adds non-number words (e.g. letters) random from 9 • Student is assisted by visual cues (e.g. finger counting, nodding, tapping by student or teacher)	1 2 3 4 5 – 7 8 (thinking) 6 5 3 10

Other impacting elements related to the task

Gesture: Describe gesture (e.g. touches objects, points only, eye points, other body movements – rocking, head nodding) Which hand was used?	Comments: Nodding head as counts	Attention: Cannot focus on task (e.g. distracted by objects or environment)	Comments: good focus
Organisation: Describe organisation (e.g. organises materials prior to counting, starts from one end and moves to the other, counts objects adjacent to each other)	Comments: /	Verbalisation: Describe verbalisation (e.g. counts out loud, sub-vocalises, no lip movement, articulation)	Comments: three = 'free'
Fine/gross motor skills: (e.g. drops/difficulty handling objects)	Comments: /	Other: /	Comments: /

Suggested intervention:
- Use finger counting / number line as prompts
- practical maths activities in range of 1 – 5
- regular counting practise inc songs/fast/slow etc
- speech therapist to assist with 'th' articulation

Figure 1. The student has a secure count to 5, but then skips 6. After 8 the count become random. The student appears to be assisted by head nodding and has difficulties articulating 'th'.

quantities to three, gradually extending to larger quantities. We also encouraged children to move the objects as they counted, to ensure objects were not counted twice (Figure 2).

Figure 2. The student moves the objects as he counts.

Children's understanding of cardinality may be lacking. When asked, "How many?", children would often recount all of the objects or select a random number. Our speech therapists pointed out that this question was quite a complex one which a child may not truly understand. They encouraged us to reduce and simplify our language as much as possible and to clearly separate out the two tasks, firstly asking the child to, "Count the objects", and then say, "How many?"

In a research study that compared children who were successful counters with those who had difficulties in counting, Geary (2001), noted some key essential differences. Successful counters typically started counting at one end of the array and moved to the other, usually in a left to right fashion. They usually counted items that were immediately adjacent to each other rather than counting in a random order. Importantly for our work, he noted that children with mathematical difficulties were more likely to count in a random and disorganised manner. We now encourage our students to organise their materials prior to beginning their count.

At a more basic level, children may have difficulties with the actual concept of number; that is, they may not get the 'three-ness' of three. We noticed that many children could count numbers such as one, two or three effectively in their everyday interactions. However, they did not have an intuitive feel for the larger numbers that we were incorporating into our counting activities. On reflection, children may have been relying on their ability to subitise small numbers and had not linked this idea with the idea of counting. We needed to explicitly integrate subitising and counting tasks by, for example, inviting children to subitise dice or finger patterns before asking them to confirm the quantity by counting.

Counting places considerable demands on working memory (Passolunghia, Vercelloni, & Schadee, 2007). This memory system has limited storage space, which can be overloaded by the complexities of the counting process. If particular aspects of the count require too much attention, if the overall task is too difficult, or if there are distractions, information will be lost and the resulting count unsuccessful. We tried to reduce the memory demands of the task to non-essential aspects, for example, by placing the objects in a line prior to counting.

Another important aspect in the journey for children to reliably count is the ability to shift attention serially from object to object. Children often keep track of their counting by the use of gesture. For children with counting difficulties the use of physical touch reduces errors (Bashash et al., 2003). Touch helps to focus the child's attention on the task, to keep track of what has been counted and what remains to be counted (Alibali & DiRusso, 1999). It may be that the act of moving the hand from one object to the next object assists children to break up the previously meaningless number string into discrete, meaningful units (Graham, 1999). Children with whom we are working in classrooms are always encouraged to express their understanding through gesture; and we insist that they touch as they count (Figure 3).

Figure 3. The student has moved the counters into a line and is using his non-dominant hand to count left to right by touching.

Fingers may be used in other aspects of counting as well. Children with word retrieval difficulties may express their understanding of cardinality by showing the pertinent number of fingers rather than expressing their understanding in words. Butterworth (1999) argued that fingers

may be a bridge between a child's innate counting ability and the development of a mature counting system. He proposed that unless a child can represent a cardinal quantity by representing it with their fingers then their true understanding of quantity might be questioned. We actively encourage the use of fingers in all aspects of the count. (Figure 4).

Figure 4. The student has made various versions of 7 and can show the number on her fingers.

A number of studies (Andres, Seron, & Olivier, 2007; Sato & Lalaina, 2008) have investigated which hand is typically used for finger counting. Results are not consistent across age groups or cultures; however, the dominant writing hand is not necessarily used as a preferred hand when counting. In our classroom, we noticed that children who used a combination of two hands to touch or move objects as they counted most frequently made errors. We now encourage our children to use one preferred hand to touch as they count.

Brain imaging has shown that the part of the brain that is activated for finger movements is very close to that used for number. Damage to this part of the brain can, amongst other things, result in finger agnosia, the inability to distinguish each finger individually without visual cues (Lebrun, 2005). Training children to improve their ability to differentiate between their fingers as well as finger dexterity and strengthening has been shown to improve a number of numerical tasks including finger counting (Gracia-Bafalluy & Noël, 2007), although there has been some debate about the validity of these findings (Fischer, 2010). Our occupational therapists encourage us to deliberately incorporate fine motor actions into every aspect of our programming (Figure 5).

Figure 5. Developing finger dexterity while completing a rainbow for science.

Finally, teachers have a long-established belief in the usefulness of manipulative materials to practice one-to-one correspondence. For some children, however, the manipulatives themselves may be so rich with interest that they distract from the counting task. Rich manipulatives may put pressure on the working memory system as children focus on the irrelevant aspects such as colour, movement or the possibilities of play. Rather than seeing the objects as symbolically representing a set of items, they may persevere on the superficial characteristics of the individual objects making a meaningful count impossible. The research by Petersen and McNeil (2013) with Year 2 students found that rich manipulatives had a huge effect on the level of task-irrelevant behaviours in which the students engaged. In our current practice, we prefer the counting objects to be small wooden cubes as these are easy for children with fine motor difficulties to grasp.

Summary

In summary, our practice in teaching children to count has developed in small but important ways. Rather than focus on the broad topic of 'counting' in our lessons, we now focus on the sub-skills of counting. We are becoming more adept at noticing subtle differences in children's counting behaviours during both targeted lessons and children's informal conversations and day-to-day counting activities. We waste less time on teaching what children already know and have become more skilful at choosing the next skill to teach. We hope that teaching colleagues will find the Glenleighden Counting Analysis as useful in this process of discovery as we have.

References

Alibali, M. W. & DiRusso, A. A. (1999). The function of gesture in learning to count: More than keeping track. *Cognitive Development, 14*(1), 37–56.

Andres, M., Seron, X. & Olivier, E. (2007). Contribution of hand motor circuits to counting. *Journal Of Cognitive Neuroscience, 19*(4), 563–576.

Baroody, A. J. (1986). Basic counting principles used by mentally retarded children. *Journal for Research in Mathematics Education, 17*(5), 382–389.

Bashash, L., Outhred, L. & Bochner, S. (2003). Counting skills and number concepts of students with moderate intellectual disabilities. *International journal of disability, development and education, 50*(3), 325–345.

Butterworth, B. (1999). *The mathematical brain.* London: Macmillan.

Fazio, B. (1996). Mathematical abilities of children with specific language impairment: A 2-year follow-up. *Journal of speech and hearing research, 39*(4), 839–849.

Fischer, J. P. (2010). Numerical performance increased by finger training: A fallacy due to regression toward the mean? *Cortex, 46*(2), 272–272.

Fuson, K. (1988). *Children's counting and concept of number.* New York: Springer-Verlag Publishing

Geary, D. (2001). Numerical and arithmetical deficits in learning-disabled children: Relation to dyscalculia and dyslexia. *Aphasiology, 15*(7), 635–647.

Gracia-Bafalluy, M. & Noël, M.-P. (2007). Does finger training increase young children's numerical performance? *Cortex, 44*(4), 368–375.

Graham, T. A. (1999). The role of gesture in children's learning to count. *Journal of experimental child psychology, 74*(4), 333.

Lebrun, Y. (2005). Gerstmann's syndrome. *Journal of neurolinguistics, 18*(4), 317–326.

Passolunghia, M. C., Vercelloni, B. & Schadee, H. (2007). The precursors of mathematics learning: Working memory, phonological ability and numerical competence. *Cognitive development, 22*(2), 165–184.

Petersen, L. A. & McNeil, N. M. (2013). Effects of perceptually rich manipulatives on preschoolers' counting performance: Established knowledge counts. *Child development, 84*(3), 1020–1033.

Sato, M. & Lalaina, M. (2008). On the relationship between handedness and hand-digit mapping in finger counting. *Cortex, 44*(4), 383–399.

Appendix

The Glenleighden Counting Analysis

Student name: Date of assessment:
Date of birth: Assessed by:

Task/tasks:

Verbal Count	Comments
Verbal number count: • Counts correctly to ... • Skips or inserts number word • Random number words/adds non-number words *(e.g. letters)* • Student is assisted by visual cues *(e.g. finger counting, nodding, tapping by student or teacher)*	
Correspondence	**Comments**
Student counts and points: OR Teacher points, student counts: OR Teacher counts, student points: • Verbal count matches movement (too fast/slow) • Continues counting after all objects accounted for • Stops counting before all objects accounted for • Counts the same object more than once • Skips over an object • Recycles numbers (says same number more than once) • Touches the same object more than once	
Cardinality	**Comments**
Student describes "how many": • Recounts all the objects and gives correct answer • Recounts all the objects and gives incorrect answer • Random guess	

Other impacting elements related to the task			
Gesture: Describe gesture *(e.g. touches objects, points only, eye points, other body movements – rocking, head nodding)* Which hand was used?	Comments:	Attention: Cannot focus on task *(e.g. distracted by objects or environment)*	Comments:
Organisation: Describe organisation *(e.g. organises materials prior to counting, starts from one end and moves to the other, counts objects adjacent to each other)*	Comments:	Verbalisation: Describe verbalisation *(e.g. counts out loud, sub-vocalises, no lip movement, articulation)*	Comments:
Fine/gross motor skills: *(e.g. drops/difficulty handling objects)*	Comments:	Other:	Comments:

Suggested intervention:

Figure 6. The Glenleighden Counting Analysis.